INFLUENCE OF AGGLOMERATION PHENOMENON IN MACHINING OF AISI D2 HARDENED STEEL USING NANO CHROMIUM POWDER MIXED-EDM

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"I dedicate this effort to the biggest hearts who made me a good man: my dear mother, my late father Abdulridha Abbas, to my partner in dreams and ambitions my loving wife, to my dear son, to all who supported and prayed for me, I would like to tell them, I thank you from my heart and ask Allah to accept this work. Ameen yarab."

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ABSTRACT

The Powder Mixed-Electrical Discharge Machining (PMEDM), as an influential environment, has been proven to overcome the challenges of dielectric liquids impedance, machinability, and surface integrity problems. Also, the additive powder particles played a vital role in this enhancement. Nevertheless, this environment suffers from the powder agglomeration phenomenon, as abnormal behaviour, resulting in the dropping of the performance of PMEDM. Accordingly, the present work aims to neutralize this phenomenon during machining AISI D2 hardened steel in PMEDM environment by employing 10, 15, and 20 Amps; 20, 25, and 30 μs; 2, 4, and 6 g/L for peak current (I_P), pulse duration (T_{on}), Nano Chromium Powder (NCP) concentration (P_C), respectively. These parameters, which are produced by Finite Element Analysis (FEA), predicted the boundaries, as the pilot procedure, to avoid the collapse of the removal operation. Digital Balance, SJ400 Mitutoyo, Shimadzu Vickers's tester, and SEM/EDS-Hitachi SU-1510 were invested to specify the Material Removal Rate (MRR), Tool Wear Rate (TWR), average surface roughness (R_a), Microhardness (MH), Recast Layer Thickness (RLT), and agglomeration ratio (%AG) after machining. Depending on Energy Dispersive X-Ray Spectroscopy (EDS) observations before and after machining stages, the weight percentage of chromium element reduced from 7.78% to (3.12% to 6.68%). Hence, NCP particles have not agglomerated in the interelectrode gap zone. Furthermore, the carbon and other elements agglomeration contributed in enhancing the microhardness from (655 to 675) HV to (784 to 911.65) HV. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)-Analyses of Variance (ANOVA)-Response Surface Methodology (RSM), as hybrid optimization, boosted the composite desirability of Multiple-Response optimization produced by RSM from 0.6153 to 0.9997. Moreover, this hybrid technique has determined I_P = 10 Amps, T_{on} = 30 μs, and P_C = 2 g/L; I_P = 20 Amps, T_{on} = 20 μs, and P_C = 6 g/L, as the optimal and worse cases, respectively. Accordingly, the predictive cost, according to the optimal-case, has declined by 40.23% as compared to the worse case.

ABSTRAK

Pemesinan nyahcas elektrik dengan campuran serbuk (PMEDM) telah terbukti sebagai satu kaedah teknologi pemesinan berdaya maju yang dapat mengatasi masalah impedans cecair dielektrik, kebolehmesinan dan masalah kualiti kekasaran permukaan. Partikel-partikel bahan tambah serbuk juga memainkan peranan penting dalam proses penggalakan tersebut. Namun begitu fenomena aglomerasi serbuk semasa PMEDM berlangsung telah mengakibatkan penurunan prestasi pemesinan tersebut. Maka, dalam kajian ini, proses peneutralan aglomerasi serbuk semasa pemesinan keluli tempa keras AISI D2 semasa PMEDM telah dijalankan dengan beberapa parameter seperti Arus puncak (I_P) - 10, 15, dan 20 amps, Tempoh denyutan (T_{on}) - 20, 25, dan 30 µs,; dan Kepekatan serbuk kromium-nano (NCP) - 2, 4, dan 6 g/L. Semua parameter tersebut dihasilkan melalui analisa elemen terhingga (FEA) yang telah meramalkan sempadan perintis bagi prosedur halangan aglomerasi serbuk semasa pemesinan EDM. Penimbang digital, pengukur kekasaran permukaan (SJ400 Mitutoyo), pengukur kekerasan permukaan (Shimadzu Vickers's tester), dan mikroskop pengimbasan elektron-spektroskopi penyebaran tenaga X-ray (Hitachi SU-1510) telah digunakan dalam menentukan kadar penyingkiran bahan (MRR), kadar kehausan perkakas (TWR), purata kekasaran permukaan (R_a), kekerasan permukaan mikro (MH), ketebalan lapisan tuangan permukaan (RLT), dan peratus aglomerasi (%AG) selepas proses pemesinan. Bergantung kepada pemerhatian ke atas permukaan sebelum dan selepas pemesinan menggunakan spektroskopi penyebaran tenaga X-ray (EDS), peratusan berat elemen kromium telah berubah daripada 7.78% kepada 3.12% dan 6.68%. Lantaran, zarah NCP tidak berjaya teraglomerasi di zon jurang antara-elektrod. Tambahan pula, pengaglomerasian karbon dan unsur-unsur lain juga menyumbang dalam meningkatkan kekerasan permukaan mikro dari 655 hingga 675 HV ke 784 hingga 911.65 HV. Penggunaan teknik pengoptimuman hibrid RSM-ANOVA-TOPSIS telah berjaya menggalakan keinginan komposit dalam teknik pengoptimuman respon pelbagai (MRO) yang dihasilkan oleh RSM dari 0.6153 hingga 0.9997. Tambahan pula, teknik hibrid ini telah berjaya menetapkan nilai I_P = 10 Amps, T_{on} = 30 µs, dan P_C = 2 g/L sebagai parameter optimum, manakala I_P = 20 Amps, T_{on} = 20 µs, dan P_C = 6 g/L sebagai parameter terendah. Dengan itu, kos ramalan daripada parameter optimum telah menurun sebanyak 40.23% berbanding dengan parameter terendah.

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